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A TREATISE ON ELECTRICITY:

WHEREIN

Its various *phænomena* are accounted for, and the cauſe of the *attraction* and *gravitation* of ſolids, aſſigned.

TO WHICH IS ADDED,

A ſhort account, how the electrical *effluvia* act upon the animal frame, and in what diſorders the ſame may probably be applied with ſucceſs, and in what not.

By FRANCIS PENROSE
Surgeon at *Biceſter*.

They who are univerſally allowed the very greateſt, and wiſeſt of men, have been, and ſtill are, intent upon the making of *obſervations*, and *experiments*: and ſurely that muſt be in order to ſome further end. Theſe would be vain, and wholely uſeleſs, were not ſome reflections made, ſome concluſions drawn, ſome theory or hypotheſis raiſed from them.

Woodward's ſtate of *phyſick* and of *diſeaſes*, p. 55.

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ON ELECTRICITY.

THE many ſurpriſing effects of *electricity*, and the great cures performed by it, one would imagine, ſhould awaken the attention of all philoſophers and phyſicians; but as theſe cures have been effected by random experiments, every body has admired, but no body ſeems to have conſidered how, or by what means, they were performed. Whence

Notwithſtanding all theſe ſurpriſing *phænomena*, from which many have entertained hopes of a great addition to the healing art; yet not one tolerable account has been given, how, or from what cauſe, theſe *phænomena* proceeded; except what has been done by Mr. *Freke*, ſurgeon to *Bartholomew hoſpital*; whoſe admirable piece ſhews the great penetration of its worthy author, with whom I ſhall join in thinking "it may poſ-"ſibly be the beginning of much good."

One

One would think, this ſilence, on ſo intereſting a ſubject, *in this enlightened age*, can proceed from nothing but a prejudice in favour of wrong principles of philoſophy: That this is certainly the taſte of the preſent age, M. *Freke* ſeems very well convinced; for, at the end of his pamphlet, he takes notice of a ſhow-man, who, "having "publiſhed ſome experiments in electricity, and "hearing that Mr. *Freke*'s piece was publiſhing, "own'd, he was much affrightened, becauſe of "the hard fate, as he ſaid, of his bookſellers; "but, before he had read two pages, he likewiſe "owned he had recovered his ſpirits, when he "found Mr. *Freke* pretended to think for him-"ſelf, and did not let Sr. *Iſaac Newton* think for "him."

Now, if all perſons would take the ſame freedom of thinking for themſelves, as Mr. *Freke* has done, I doubt not but we ſhould ſoon be as much aſhamed of mentioning the *attraction* of *gravitation*, and the *attraction* of *coheſion* &c. as we now are of the *occult qualities* of the ancient philoſophers; and ſhould perhaps, then agree with him, when, ſpeaking of electricity, he ſays, that "it is a ſubject which can, with "more nobleneſs and dignity, employ the mind "of man, than any he can think of, relating to "the ſublunary part of the world. For by it

"you

"you may be acquainted with the immediate "officer of God Almighty, which he ſeems to "ſend to all things living: Nay, this power, (ac- "cording to his conception,) ſeems to be the "cauſe, under HIM, both of life and death. "And when it may be more fully underſtood, it "may afford us means, whereby we may be bet- "ter enabled to reaſon more intelligibly, than "now we can, concerning various operations in "nature." Therefore,

In the following eſſay, I ſhall endeavour to ſhew,

I. How, and from whence, this electrical fire and force are produced; in doing of which I ſhall make ſome obſervations, in order to ſhew that we may form a more exact idea of moſt of the great operations of that complete machine, the univerſe, from electrical experiments, than can be attained by any other means: I ſhall alſo produce ſome experiments which demonſtrate, that the terraqueous globe has no *attraction*; nor a ſolid body, falling towards the earth, any *gravitation*; after which, I ſhall bring other experiments to prove what is the cauſe of *ſolidity*, and by what means bodies *gravitate* towards the earth.

II. How

II. How this electrical fire and force act upon the animal frame, and in what diſorders they are likely to be of benefit, and in what not.

I. We are certain, that this electrical fire is produced, either from the glaſs globe, or the air that ſurrounds it. As to the glaſs globe, Mr. *Freke* has fully proved it cannot proceed from that; "Becauſe nothing, we know of, can ſend "out of it a quantity of matter, but there muſt "be leſs of that matter remaining, after it has "been ſo diſcharged; whereas it cannot be "ſhewn, but that the glaſs globe, after ever ſo "many times uſing, remains as fit for the ſame "uſe, as at firſt." From hence we aſſert, that this fire muſt proceed from the ſurrounding air being acted upon by the glaſs globe; and our inquiry muſt be, how, and by what means, fire is produced by the glaſs globe being made to act upon the air; by which inquiry we ſhall find, that *air*, *light*, and *fire* are of the *ſame ſubſtance*, or *eſſence*; only differently modified, and appointed for performing different actions: that air (by being divided or broke to pieces) produces light; and, if that action is ſtill encreaſed, it produces fire. Now as the greateſt friction or attrition are neceſſary to produce fire, ſo fire, when it is once produced, having received the greateſt force, of conſequence *acts* with the greateſt force;

and

and light, with a leſs; ſo, wherever there is the greateſt quantity of theſe ſmall particles of air, (which we call by the name of fire) in proportion to what we call groſs air, there the action muſt be the greateſt; by which means the ſaid fire or light will expand itſelf, 'till, by mixing with what we call groſs air, it becomes of an uniformity with it. Now therefore, as experiments are the ſure way either of proving or diſproving any *hypotheſis*; ſo, to illuſtrate this, I ſhall produce ſome experiments both from Mr. *Freke*, and other authors of unblemiſhed credit, which prove that air is convertible into light and fire, and alſo that light and fire are convertible back again into air; and likewiſe, as ſome parts of the air are preſent in all places and things, that therefore, whenever a violent action either of ſolids or fluids is brought on, there light, fire, or heat, are produced.

To prove this, Mr. *Freke* has brought, two very ſimple, common, but good experiments --- Firſt, if you ſlide a wax thread, or ſmall rope, through your fingers, it will burn them; ſo likewiſe fire is produced, by rubbing two hard bodies together, or two ſticks; or, as is very often the caſe, a cart or coach wheel will take fire, for want of greaſe.

Another no ſmall proof of this, is what Mr. *Freke* has mentioned, viz. that in the year 1703, in the night of the great hurricane and high wind, in the ſtrongeſt part of the tempeſt, great quantities of fire were ſeen paſſing ſwiftly over the hills in the neighbourhood of *Warham* in *Dorſetſhire*. The cauſe of which fire ſeems very eaſily accounted for, according to the above theory, which might otherwiſe perhaps, elude the ſearches of our greateſt philoſophers: for in this phænomenon it is plain, that the attrition of the particles of the air was ſo great by the motion of the wind, as to produce fire or light. Mr. *Freke* has ſome other obſervations, which much ſtrengthen the above theory, viz. that in tempeſtuous weather, at ſea, great flakes of fire are frequently ſeen paſſing, not only in the air, but on the water. The like is alſo obſerved, in the night time, when the ſurface of the water is diſturbed with the feathering of oars, or by a veſſel or boat paſſing ſwiftly through it. This light or fire *in ſtorms* is no new obſervation; for Mr. *Boyle* ſays, it is common in ſtorms for the fire called *Helena*, *Caſtor*, and *Pollux*, to hover about the maſts of ſhips. And, indeed,

To ſhew that fire or heat are produced in any place, or thing, where there is a ſufficient motion, ſeems not to be very difficult; for water is

the

the oppoſite to fire; and yet, by mixing water and ſpirit of wine *ſuddenly* together, a heat enſues; and this will happen if they have been ſeparated ever ſo often; but this heat vaniſhes again after they are mixed, or as ſoon as the *motion* of their parts ceaſes. The like will happen by mixing ſalt of tartar and water. This phænomenon ſeems to proceed from the diſpoſition and texture of the ſalt; whoſe pores are made of ſuch a proper ſize, that, on receiving the water by the preſſure of the atmoſphere into them, the texture of the ſalt may be thereby broken, and its parts put *into motion*; which *motion* cauſes an *attrition* of the air, and ſo produces a ſenſible heat.

Boerhaave has another obſervation, which ſeems to prove to a demonſtration, that fire or heat is cauſed by an *attrition* of the air; which obſervation I ſhall give in his own words. "A "cannon ball, ſhot in the winter time, will fly "600 feet in a minute through the cold air, "which makes a greater reſiſtance than any "wind, the moſt rapid of which only moves "22 ½ feet; hence it appears how much *friction* "the ball muſt have undergone in its paſſage, "which by the way did not proceed in a right "line, but by its whirling motion continually "deſcribes a cycloid with every point of its body.

" When it falls, it is found quite hot; notwith-
" ſtanding in its whole paſſage, it had continu-
" ally met with cold air. This heat could not
" have ariſen from the flaming gunpowder,
" whereby it was exploded, ſince it only remain-
" ed in that flame, an incredible ſmall ſpace of
" time, in which it is by no means credible ſo
" ſolid a body ſhould have acquired ſuch a heat;
" which is much more naturally accounted for
" from the great attrition of the ball, driven with
" ſuch a velocity through the air, and repelled by
" a wind, which is above 27 times ſwifter than
" the ſtrongeſt wind hitherto obſerved." *Boer-haave*'s Chym. by *Shaw*, Vol. 1. pag. 244.

I ſhall mention one more experiment from Mr. *Boyle*, which proves that *air* is not only convertible into *light*; but that it may afterwards be forced through glaſs, and thereby the ſame *vacuum* be made that is by an air pump. " Liquid
" phoſphorus being put into a vial, when it was
" diſpoſed to ſhine in the dark, the cavity of the
" vial above the liquor ſeemed to be full of whi-
" tiſh fumes, though at other times tranſparent.
" The vial, when cloſe ſtopped, was not lumi-
" nous in the dark, but the light or flame ap-
" peared as ſoon as it was expoſed to the air, and
" the vial was unſtopped; and that the occaſion
" and propagation of this flame depended on the

" con-

" contact of the air, appeared, ſince agitation
" would not kindle it, but when the bottle was
" unſtopped, the kindled flame would gradually
" be propagated downwards; the flame always
" appeared moſt vivid the nearer the air, and
" when it was extinguiſhed, it firſt diſappeared
" in the bottom, and then expired at the top.
" When the Vial was unſtopped for ſome time,
" when it was ſtopped again, the air that had lei-
" ſurely inſinuated itſelf would cheriſh the flame
" for an hour or two. It was obſervable, that
" when the air had been long pent up with this
" ſhining liquor, its reſiſtance would be ſo weak-
" ened, that when the vial was unſtopped, the
" external air would preſently ruſh in with vio-
" lence, from whence appears the intereſt of the
" air in propagating the ſhining of this liquor.
" The agitation before the vial was unſtopped
" would not kindle the light; yet when it was
" opened, it would be increaſed by it, and even
" when it was in its dull ſtate, if I poured a lit-
" tle of it upon my hand, and rubbed it with
" my finger, it would preſently become vivid,
" and emit ſtore of luminous rays, as well as
" fumes very offenſive to the noſtrils; and when
" I ceaſed to rub, and the luminous quality was
" loſt, it would be renewed again by a repeated
" attrition; but in a little time its lucid virtue

" would

"would decay." *Boulton*'s Epitome of *Boyle*'s works, vol. 2. pag. 246. From theſe experiments it may be obſerved, that this liquid phoſphorus could not be made to emit light, without a communication with the air, not even by the utmoſt agitation; though when it had a free communication with the air, a ſmall agitation greatly increaſed the quantity and ſtrength of the light; that, whenever the air was admitted to join it, a violent inteſtine motion came on, by which motion or attrition, light was not only produced, but alſo a great deal of the liquid was carried off by it; which might be perceived either by the ſight, or ſmell. And when the vial had been long without a cork, by which means it was filled to the utmoſt with air, the light would continue a conſiderable time after the vial was ſtopped. We likewiſe find, that, after the vial has been ſtopped ſome time, and the liquor has acted upon the air as much as it poſſibly can, there is not only a leſs quantity of groſs air than there was when the vial was firſt ſtopped, but that there is the ſame *vacuum* as is made by the air pump; for as ſoon as ever it is unſtopped, the air preſſeth in with violence, the fluid above the phoſphorus (within the vial) being of a more ſubtle nature than the air without.

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This experiment ſeems ſufficiently to prove, that air and light are of the ſame eſſence or ſubſtance; for we are certain that groſs air entered the vial, and, when it was firſt ſtopped, the quantity of groſs air was of an uniformity with the air without the vial; but at its being opened, we are aſſured, there was a leſs quantity than when it was firſt ſtopped; for the air without preſſeth in with the ſame violence it does into the exhauſted receiver of an air-pump; by which we may be aſſured, that ſome parts of the air have paſſed the vial in form of *light*; and, as the pores of the glaſs are not big enough to admit groſs air to return, the conſequence muſt be, that there is a leſs quantity of groſs air in the vial at the opening, than there was, when it was firſt ſtopped.

Fire and light are eaſily proved to be diſperſed through the whole air, from the immediate action of *ſpeculums*; and that air itſelf is of the ſame ſubſtance with fire ſeems very plain; for as fire cannot ſubſiſt without air, (and in proportion to the quantity of air forced into the fire, in ſuch proportion will be the force of the fire;) ſo, neither can fire act but on the outſide of bodies next the air; for even the moſt inflammable bodies can only catch fire on their outermoſt ſurface contiguous to the air; and fire in

action,

action, if immerged in a body of the moſt inflammable matter, ſo as to leave no lighted part above ſuch ſurface in the air, will be ſo far from kindling the inflammable body, that itſelf will be extinguiſhed. Thus "if a flaming brimſtone "match be plunged into the higheſt rectified ſpi-"rit of wine, the ſpirit of wine will extinguiſh "it as intirely, as if dipped in cold water; it "will alſo extinguiſh a live burning ſparkling "coal; but in the former experiment, if the leaſt "bit of the burning match remains above the "ſpirit of wine, it will then catch fire, and the "flame will preſently ſpread over the whole ſur-"face." This is an experiment of the great *Boerhaave*, in the firſt vol. of his chymiſtry, by *Shaw*, pag. 316.

All theſe experiments, I think, prove to a certainty, that air is convertible into light. I ſhall now bring one experiment, from *Boerhaave*, Vol. 1. p. 998. which proves, that fire or light may be changed into air.

"If a ſpherical glaſs vial be kept in a glaſs-"houſe furnace, till ready to melt, and then be "hermetically ſealed in that heat, and ſuffered "to cool; if now, it be held inverted, under "cold water, and the end of the neck be care-"fully broken off, the water will be violently "forced into it, and fill the glaſs, but ſo as to

"leave

"leave a bubble of true elaſtic air at the bot-
"tom."

The above experiments prove, that, whenever air is ſufficiently divided or broken to pieces, light is produced; ſo that the light or heat in electricity, is no other than, we find, may be produced ſeveral other ways. For the air being violently rubbed or ground to pieces between your hand and the glaſs globe, whirled briſkly about, the air between your hand and the globe is ground ſo ſmall as to be in the form of *light*, which is expanded or ſent off from the glaſs globe in the ſame manner as *light* from a candle, or other luminous body; which emiſſion is continually ſupplied by the common air preſſing in between the rays of *light*, emitted from the glaſs ball. That this is the method, by which it acts, ſeems very clear: for you may not only hear the hiſſing noiſe of the air preſſing towards the globe, but alſo plainly feel the air with your hand, near the globe or tube.

The chief reaſon (and what has been our great misfortune) that we have not been able to diſcover the cauſe of electricity, ſeems to be the leaving that philoſophy, which has been *revealed* to us, and putting in its ſtead *theories* of *our own invention*. For, if we had conſidered (from the *revealed* account that is given us of the formation

of

light) the *method* of its *firſt* production, we ſhould not be at ſuch a loſs to account for that light in electricity, as we hitherto ſeem to have been; for we are *there* told, that the *heavens*, or airs, were created in a ſtate of *darkneſs*, or inactivity; and that the firſt thing God did, was to cauſe a *motion*, or *wind* amongſt the airs; which *motion* was to *continue*, and *encreaſe*, till it produced *light*; and, after this *light* was produced, God called it *Day*, or as it is expreſſed in the original, *tumultuouſneſs*; it being produced from the impetuous or violent motion of the airs: and the *darkneſs* he called *night*, or, as it is likewiſe expreſſed, the time when this *languiſhes* or *decays*; for the *congealing* or *thickning* of the air, by which *darkneſs* is produced, is in proportion as the *force* of the *light* abates.

By all which, I think, we may be aſſured, that the *light*, and all the *phænomena* produced in electricity, are cauſed by a violent *friction* or *grinding* of the grains of air between the glaſs globe and the hand.

To illuſtrate and prove, that this is the method by which the electrical *light* is produced, I ſhall bring ſome experiments, from Mr. *Haukſbee*, which, I imagine, will make it indiſputable. In his firſt and ſecond experiments, he ſhews us, that by dropping mercury on a glaſs in an exhauſted

hauſted receiver, the *action* of the mercury on that ſubtil fluid gives the mercury the appearance of fire; but obſerves, that in all theſe experiments on mercury, no *light* is to be obtained without *motion*, and that the ſame motion which produced this light in *vacuo*, did not produce it, when given to mercurial globules in *open air*. This experiment ſhews us, that there was a larger quantity of *light* in the exhauſted receiver than when it was filled with common air; nay farther, that the *ſubtil fluid* contained in the exhauſted receiver, was *light*; but, for want of *motion*, was not perceptible by our ſenſes; but by ſo ſmall a motion as that of the deſcending mercury, it was puſhed forward in the ſame manner, as *light* from a candle, or other luminous bodies. We alſo find, that the ſame experiments performed in an *unexhauſted* receiver, would not produce the *phænomenon* of *light*; which one might eaſily ſuppoſe to be the caſe. For in the *exhauſted* receiver, any the leaſt *motion*, that is ſufficient to *puſh* this ſubtil fluid *(light)* from one place to another muſt give us the perception of *light*; but in the *unexhauſted* receiver the *motion* or *friction* muſt be great enough, not only to *puſh* the air from place to place, but alſo to *break it* ſo ſmall, as to be in form of *light*: which he ſhews us by his third, fourth, and fifth experi-

ments to be the caſe; for by theſe experiments he produced *light* in an *unexhauſted* receiver; but then the *motion* or *agitation* was required to be much *greater* than that which produced *light* in *vacuo*. The difference of theſe two *lights was very conſiderable*, and conſiſted particularly in this, that the luminous particles are *diſtinct* and *ſeparate* in the experiment performed in the *open air*; and *united* and *blended* into one continued body of *light*, in the other experiments in *vacuo*; which difference proves to a demonſtration, that the exhauſted receiver was full of nothing but *light*; for, on ſhaking the mercury therein, the whole body of the receiver ſeemed to be *one continued body* of *light*; but on ſhaking the mercury with ever ſo great a violence in the common air, it ſeemed full only of *little*, *bright*, *twinkling ſparks*; and not one continued body, as in *vacuo*. For, as the appearance of *light* is produced in the common air, by the *friction* of the mercury againſt the glaſs receiver, *breaking* or *grinding* the air to pieces (which ſmall particles put on the form of *light*) ſo, when the common air *preſſes* in between theſe ſmall particles, the appearance muſt be, and cannot be otherwiſe than is ſhewn by theſe experiments.

Theſe

Theſe many and various experiments abundantly prove, that *light* is produced as above deſcribed; and not, as the generality of people have imagined (from that miſtaken notion of *action* being performed by *ſolids* and not by *fluids*) that this electrical *light* proceeded from the glaſs globe, emitting, what they call, *electrical effluvia*, which has been ſhewn before to be impoſſible; becauſe if any quantity of matter ſends off part of its own body, there muſt be leſs of that body remaining, than before the above matter was ſent off, which we find is not the caſe of the glaſs globe; and to prove that it does not, I ſhall bring one experiment more from Mr. *Haukſbee* which will put it beyond doubt.

Pag. 27. he ſhews us, that by a violent *attrition* of *woollen* againſt *woollen* in *vacuo*, he produced *light*, as well as from any *hard* or *electrical* body; but not ſo vivid, nor in ſo large a quantity. Now, as woollen is reckoned by all to be a *non-electrical* body, it ſhews us that the *light* muſt proceed from the *attrition* of the air, and not from the *electrical body*, as has been falſely imagined.

As *light* may be produced by other methods than have been yet deſcribed, as from *rotten wood*, *fiſh*, *meat* &c. I ſhall endeavour to give an account, how, and in what manner, that *light* is

pro-

produced. Mr. *Boyle* (in vol. 2. p. 233. of the epitome by *Boulton)* tells us, that by putting *rotten wood*, *fiſh*, *fleſh* &c. in the receiver of an air-pump, and then extracting the groſs air, they all, in a little time, loſt their *ſhining* or *luminous* quality; but, upon a re-admiſſion of air, this *luminous* quality returned. From which we may learn, that the air is eſſentially neceſſary to continue this *light*; and, of conſequence, that this *light* is produced by the *action* and *re-action* of the air on the body, which cauſe an *inteſtine motion* of its parts; and thereby the emiſſion of the ſaid light; for when any thing begins to ferment and *putrify* (which cannot be performed in any place, but where the groſs air is preſent) the *inteſtine motion* of its parts is thereby *increaſed*; which *motion* acting upon the air preſſed into it, the air is thereby *ground* very ſmall, and by the continual preſſure of the atmoſphere is ſent out ſo ſmall, as to be in form of *light*. --- In the common *fermentation* of liquids, when it riſes to any height, thoſe particles of *light* being *ſtopped*, and *entangled* by the *watry parts* of the fermenting maſs, thereby produce *heat*; and ſome mixtures will produce *light*, *heat* and *flame* on fermentation; as *ſteel*, *water*, and *ſulphur*.

By

By theſe experiments we have a clear idea of the means and method by which *fermentation* is performed, which operation has been hitherto unintelligible. From hence we may likewiſe ſee the reaſon why, in an air either *too hot* or *too cold*, *fermentation* cannot be performed; for in an air *too cold*, the preſſure is *too great*, and alſo the grains of air *too large* to *enter* and *divide* the thing to be *fermented*; by which means the *motion* of its parts requiſite to *fermentation* is prevented; but in air that is *too hot*, there muſt be juſt the contrary effect, for there the parts of the thing to be *fermented* are ſo far *expanded*, and the air ſo *rarified*, as to paſs through the body with little or no obſtruction, and of conſequence to produce little or no *inteſtine motion* of its parts; and that there is in *fermentations an inteſtine motion* of the parts of a *fermenting* liquid, is eaſily diſcernible by the naked eye. This alſo gives us the reaſon, why the *glow-worm ſhines* only in the ſummer months, when the air is greatly *rarified*, or *divided*, and then requires but a ſmall *motion* to give it the form of *light*.

The *light* proceeding from *diamonds* &c. ſeems to be eaſily accounted for from the *motion* of the *airs*; that there is a *perpetual motion* of the *airs*, may be proved by the following experiment. In a ſtill place, ſuppoſe a cloſe darkened

room,

room, illuminated only by one ſmall hole in the window ſhutter; where, if a perſon at reſt views the enlightened current of air ſideways, as it extends along the room, he will perceive a *ſurpriſing motion* of the duſty atoms therein, *perpetually rolling and toſſing* about *with great rapidity*. This *motion* muſt be very *conſiderable*, as it is *perpetual*, and puſhed on with the power of *gravity* in the air equal to a column of water 33 feet high. By this *action* on *diamonds*, whoſe *pores* are very *ſmall*, and the bodies themſelves of ſuch a *make* and *hardneſs*, as that, when the air is preſſed on them with ſo great a *force* as that of the *incumbent atmoſphere*, the air is *broke exceedingly ſmall*, and, by the continuance of the *preſſure*, is ſent off from the body in form of *light*. We likewiſe find from experiments, that where *diamonds*, or other bodies of that kind, have not their outward parts of a proper *make*, or their *ſubſtance* of a *ſufficient hardneſs* or *cloſeneſs of parts*, to emit *light* with no greater *force*, than the preſſure of the *atmoſphere* only, then this deficiency may be ſupplied by *rubbing*; by which means the air is *ground* to pieces, and emitted in form of *light*, as is ſhewn in all electrical experiments.

One

One great property of *light*, or, as it is commonly called the *electrical effluvia*, is (as Mr. *Hauksbee* has proved from many experiments,) that it passes *through glass*, as water does through a sieve, or as if no body of matter interposed. This *light* of itself, when *pure*, or *simple*, hurts or destroys no material bodies; but when *pushed* on by the following air with *great violence*, and *meeting* with a *great resistance* from an impeding body, the *conflict* is so great, that if the following air *presses* on with *sufficient violence*, it *dissolves* or *destroys* the *solidity* of any material body. As all bodies become *solid* according to the *temperature* of the surrounding air; some retaining their *solidity* in such a degree of *heat*, as *metals* of most kinds; whilst others require a particular degree of *cold* before they become *solid*, as *water* &c. which when froze is as much a *solid* as any thing else --- this proves that the *solidity* of bodies depends on the *temperature* of the air, as will be more fully proved hereafter.

The glass globe, with the electrical experiments, seems to give a very clear idea in what manner the *sun* is *supported*, how this *terraqueous globe* and the rest of the *planets* are made to *move*, and *continued in motion*; and also, what is the cause of the *attraction* of the *sun*, *earth*, *moon* and the rest of the *planets*.

That

That the *ſun* is the chief, material, ruling agent, is very clearly revealed; as are ſome of its chiefeſt actions on the planets and the reſt of the univerſe. For, in the ſun we find a power of melting, dividing and (with the aſſiſtance of the air) expanding and ſending out the air, firſt in form of *fire*, and afterwards in that of *light*; which power ſeems to be ſo regulated, as to be able to reach the extremities of the univerſe, where it is *congealed*, *condenſed*, and *returned* back again to the *ſun*, to be again *melted*, *divided*, and ſent out as before. This action ſeems to be repreſented by water in a *ſtill*, for there the fire, forcing its way through the water contained in the *ſtill*, carries off ſome of the watry particles with it; and when it has reached the head of the *ſtill*, if it has no paſſage into the outward air, and the *action* of the fire is not great enough to break the *ſtill*, it is by the coldneſs of the ſurrounding air (or as is commonly the caſe by the coldneſs of water placed thereon for that purpoſe) *condenſed* and *returned* into the water contained in the body of the *ſtill*, there to be *rarified*, *expanded*, and ſent off in *ſteam*, as before.

We muſt ſuppoſe the ſtreams of *light* to be always acting on one ſide of this terraqueous globe, and there *dividing*, *expanding* and *rarifying* the air; the conſequence of which muſt be a kind

a kind of *vacuum*, which is immediately filled by the *preſſing in* of the *congealed air* from the extremities; and as the earth is placed in this fluid of airs, we may as eaſily conceive that the air preſſing in as above, muſt, with it, turn round the earth, in the ſame manner, and with as much eaſe, as water does a common mill-wheel, or the air a wind-mill. By theſe powers alſo the terraqueous globe is kept *ſolid* and *entire*; for, was this *force* once taken off, it would ſoon drop to *atoms*, notwithſtanding the pretended *attracting* power of its materials.

To confirm what is here advanced, I ſhall bring an experiment (which Mr. *Boyle* has laid down as a paradox) which proves that this terraqueous globe has no *attraction*, nor any *ſolid*, falling towards it, any *gravitation*; but that all bodies *are forced* to it by the *incumbent atmoſphere*, as much as water is *forced* up a pump by it (the atmoſphere) which, till the time of the great Mr. *Boyle*, was imagined to be performed by, what they called, the *ſuction* of the pump. But this is no more than has often happened in philoſophy, where when we cannot well account for any thing, we put the *effect for the cauſe*.

Mr. *Boyle* found that a *ſolid body*, as *ponderous* as any yet known, though near the top of the water it would ſink by *its own weight*, yet if it be

placed at a greater depth than twenty times its own thickneſs, it will *not ſink*, if its deſcent be not aſſiſted by the *weight* of the *incumbent water*. To prove this, he gives us a curious experiment, viz. by keeping off the *preſſure* of the water, from the *top* of the *ſinking body*, and *ſinking* it to a proper depth, he found, that the *moſt ponderous* body would be *buoyed up*, and *ſupported* by the water only. See the 2d vol. of *Boulton*'s epitome, pag. 305. This experiment ſhews us beyond all contradiction, that the *earth* has no power of *attraction*, nor a *deſcending body* any power of *gravitation*; for if it had, the farther it was ſunk in the water, the nearer it muſt be to the centre of the earth, and of conſequence the *attraction* muſt be the greater; but this, we find, is contrary to experience; ſo that the whole power of deſcending is impreſſed upon it by the *air*, or by other bodies forced upon it by the *incumbent air*. This experiment alone is more than ſufficient to deſtroy the fine theories of *attraction* and *gravitation*; it alſo ſhews us how, and by what means, two marble ſlabs, finely poliſhed, are what they call *attracted* to each other, and require a great force to ſeparate them; a force in proportion to the breadth of the ſlabs; but this has been ſhewn by other experiments to be nothing but the *preſſure* of the *air*, or *atmoſphere*;

for

for put them into an air pump, and extract the *groſs air*, and they will immediately ſeparate from each other.

One reaſon, which ſeems to have led us into the miſtake that the *ſolidity*, or *firmneſs* of bodies is not cauſed by the *air*, has been, that, for the generality, we conſider the *air*, or *atmoſphere* as *preſſing* only *downwards*; for if we had conſidered that it *preſſeth* equally *every way*, as well as *downwards*, (as *Boerhaave* in his chym. by *Shaw*, vol. 1. p. 389. has ſhew by the following experiment) I believe we ſhould not have overlooked that force, or have thought it inſufficient for this operation. "Fill three glaſs veſſels, the one of a "cylindrical figure, the other conical, the third "bellied with a cylindrical neck; let theſe be "filled to the brim with fair water, and covered "with a ſingle piece of paper, ſo as to touch the "ſurface of the water, and by preſſing it down "with the hand, prevent the external air inſi-"nuating between the paper and the water; if "the glaſſes be now inverted, whilſt the paper "remains cloſe with the palm of the hand, and "the hand be afterwards gently withdrawn, the "water will ſtill remain in the glaſſes. The ſame "holds true, though the glaſſes be held horizon-"tal, or in any other poſition." As the cauſe of the *ſolidity* or *firmneſs* of bodies is the *preſſure* of the

the *air* or *atmoſphere*, ſo likewiſe it muſt depend on the *make* and *ſize* of the *pores* of ſuch bodies; for bodies whoſe *pores* are *ſmalleſt*, muſt be acted upon with a greater power than thoſe whoſe *pores* are *largeſt*, or whoſe *pores* are ſo *large* as not only to admit *light*, but alſo *common air* into them. This Mr. *Haukſbee* proves by a curious experiment, for having placed two braſs hemiſpheres, of 3 ½ inches diameter, upon each other, and then extracting the groſs air out of them by the air pump, and by theſe means taking off the *reſiſtance* of the *common air* that was *within* the two braſs hemiſpheres, he ſays, it required 140 pound weight to ſeparate them; this experiment with that of the two marble ſlabs before mentioned, is a demonſtration of the *power* that keeps *ſolid bodies* from *falling* to *pieces*. And even, if theſe ſlabs are not ſo *perfectly ſmooth*, yet the weting them with water, which prevents the groſs air from *entering*, will produce the like effect. That ſolids *expand* themſelves by *heat* or *fire*, is proved by heating an iron rod in the fire: in which caſe, it is always found to be *bigger* and *longer* when *hot* than *cold*; and it was the opinion of *Boerhaave*, that cold *conſolidates* all thoſe that are called firm bodies; that is, brings that part, which we call *body* in them, into a *leſs compaſs* than before, and thus *unites* the matter there-

of

of more cloſely together: by which means the *coheſion* of the whole maſs is uſually increaſed; which makes what we call, *ſtrength* and *firmneſs* in bodies.

Having ſhewn that *ſolid bodies* have no power either of *attraction* or *gravitation*, and that their *firmneſs* or *ſolidity* depends on the *preſſure* of the *atmoſphere*; I ſhall now endeavour to ſhew, from electrical experiments, how, and by what means they *deſcend* towards the earth.

What is called the *attraction* of the *earth* ſeems to be performed in the ſame manner as that of the *glaſs globe* in electricity; the explaining of which will give us a clear idea, by what means *heavy bodies* are *forced* towards the terraqueous globe. In accounting for this electrical *attraction*, Mr. *Haukſbee* ſeems to be very clear; for, ſays he, "if by the heat and rarefac-
"tion, conſequent upon the attrition, the me-
"dium contiguous to the glaſs be made ſpecifi-
"cally lighter; then of courſe, to keep up the
"ballance, the remoter air, which is denſer, muſt
"preſs in towards the tube, and ſo carry away
"(in the torrent) the little bodies lying in its
"way, thither alſo. The various irregularities in
"the excitation, or the emiſſion and diſcharge of
"the electrical matter or light from the tube
"(which will be followed with proportional ir-
"regularities,

" regularities, in the motion and tendency of the " denſer air, towards the glaſs globe, by the hy- " droſtatical laws) may be ſufficient to account " for the various uncertain motions of the little " bodies carried towards the glaſs globe." This account of Mr. *Haukſbee*'s being ſo very clear, it is a little ſurpriſing that he ſhould allow the power of *attraction* to matter, as in ſome places he does; for this is no more than in other words, telling us, that the air round the ball is *divided* and *rubbed* or *ground* to pieces by the *friction* between the glaſs globe and your hand, and thereby made to *expand* itſelf; ſo the air preſſing in to make up that deficiency, forces every thing towards the glaſs globe, that by its number of particles is not able to withſtand the *current* of *air*, preſſing towards the globe. So in like manner near the ſurface of the earth, the ſun-beams being *reflected* by the terraqueous globe, muſt by theſe means be in a greater quantity near the ſurface of the earth, than at a diſtance from it; and ſo *divide*, *expand* and *rarify* the air near its ſurface, which *rarified* or *divided* air is forced off from the earth on all ſides, by the *preſſing* in of the air from above, which muſt of conſequence *drive* every thing before it, towards the earth. By which we find, that the cauſe of bodies *deſcending* towards the earth, is not from any *pro-*

perty

perty either of the *earth* or of the *deſcending bodies*; but that theſe are *forced* towards that, by the ſurrounding *air*, in its ſaid *motion*.

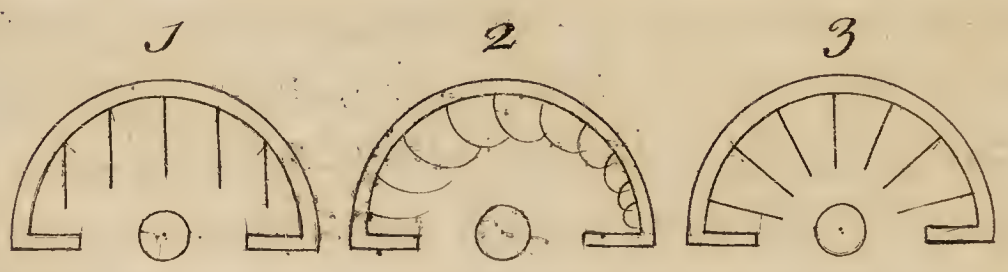
To prove that this is the method by which, in electricity, bodies are forced towards the glaſs globe, I ſhall bring an experiment or two from Mr. *Haukſbee*; and as theſe experiments prove to a certainty, that this is the manner of the *attraction* in *electricity*, it will give us little room to doubt, but that the *attraction* of the *earth* is performed in the ſame manner.

Mr. *Haukſbee* obſerved, that the *electrical effluvia* were not only perceiveable by ſight; but alſo, if the hand was held near the tube, ſeemed to make ſuch ſort of ſtrokes upon the ſkin, as a number of fine limber hairs puſhing againſt it might be ſuppoſed to do: and in order to find whether the electrical *attraction* was regular and uniform, he made the following curious experiment, ſhewing that all bodies, not too heavy, are *forced* (or, as is commonly ſuppoſed, *attracted)* to a cylindrical glaſs, equally all round, if theſe bodies are, as *they term it*, within the ſphere of its activity.

This experiment ſeemed to affect Mr. *Haukſbee* ſo much, that (ſpeaking of electricity) he ſays, "it affords us a ſort of *repreſentation* of the "*great phænomena* of the *univerſe*." Page 53.

"For

"For, ſays he, having obſerved (in electrici-
"ty) that light bodies, placed near any part of
"the rubbed cylinder, ſeemed to be equally at-
"tracted, I contrived a ſemicircle of wire, which
"I could faſten at a conſtant diſtance, making it
"encompaſs the upper ſemi-cylindrical ſurface
"of the glaſs, at 4 or 5 inches diſtance. This
"wire had ſeveral pieces of woollen threads faſ-
"tened to it at pretty near equal diſtances. The
"length of them was ſuch, that being extended
"in a direction towards the center of that imagi-
"nary circle, on the ſurface of the glaſs, in the
"plane of which the wire was placed; they
"would then reach within an inch of the cir-
"cumference of that circle: but if left to their
"own liberty, they hung in that parallel poſi-
"tion repreſented, fig. 1. The cylinder was



"placed with its axis parallel to the horizon;
"and in this poſture, it was turned ſwiftly
"round

" round; and then by the rapid motion and agi-
" tation of the ſurrounding air, the threads were
" placed into ſuch poſitions, as are expreſſed fig.
" 2. viz. they were all lifted up and bent up-
" wards from the axis of the cylinder.

" All this while, there was only the ſwift mo-
" tion of the cylinder round its axis, without any
" attrition, but now when I came to apply my
" hand to the lower part of the glaſs (ſo ſwiftly
" whirled about) and conſequently to add attri-
" tion to the former motion; the threads pre-
" ſently began to change their direction, and all
" harmonioufly pointed to the center of the circle,
" in whoſe plane the wire was placed, as in fig. 3.
" neither were they at all diſordered or flung out
" of that poſition, by the wind occaſioned by
" that violent motion (but as if there had been
" no ſuch hurry of air about them) they ſtill
" perſiſted in their central direction; I found I
" could by ſhifting the place of the attrition hi-
" ther or thither, draw the threads towards this
" or that end of the cylinder; but yet they all
" ſtill went uniformly converging towards ſome
" center in the axis of it; ſo that they formed
" themſelves into a ſort of conical ſurface.

" Farther, if the wire with its looſe threads
" was reverted, ſo as to encompaſs the lower part
" of the cylinder (as before it did the upper part)

" yet the effect ſtill anſwered with the ſame ex-
" actneſs. For the threads were all erected into ſo
" many ſtrait lines, ſtill directing themſelves to-
" wards a center in the axis of the glaſs.

" Hitherto the axis of the cylinder was placed
" horizontally; in the next place I ſet it in a ver-
" tical poſition, ſo that it ſtood perpendicular to
" the plane of the horizon; in which caſe I made
" uſe of a wire hoop, which was neceſſary to be
" placed parallel to the horizon, that it might
" encompaſs the cylinder, in the ſame manner as
" the ſemicircular wire did before: only one
" ſmall part of this wire was left open, to make
" way for the touch of the hand, which was to
" give the attrition. And the wire being thus
" placed, it was evident that the threads (without
" ſome external force to ſupport them) muſt all
" flag and hang perpendicularly downwards. Yet,
" as ſoon as the motion and attrition were given,
" the threads preſently began to be extended; and
" as if they were become ſtiff and hard, formed
" themſelves into an horizontal plane; their looſe
" ends pointing to a center in the axis of the
" glaſs, as before.

" And thus (in all ſorts of poſitions whatſoe-
" ver, both of the wire and of the glaſs too) were
" the threads acted upon by a ſort of centripetal
" force; to the laws of which they were always

" con-

" conformable. See *Hauksbee*'s experiments, page " 53 &c.

It may be obſerved in this experiment, that the *attractive* power of bodies does not lie in *ſolids*, as has been falſly imagined, neither have ſuch bodies any *centripetal* or *centrifugal* force; but that this *power* and *force* are given them from *without*. For, on placing the wire with the threads round the cylinder, they were all *forced* (or as it is often called, *attracted)* towards the *earth*; but, on giving a *violent motion* to the cylinder, they were drove from the cylinder, as if forced by a ſtrong wind; but, by applying the hand to the glaſs cylinder, they were recalled, and all pointed to a center in the axis of the cylinder: and this *central* direction might be altered at any time, by only moving the hand to different parts of the cylinder; the threads always pointing to the place where the *attrition* was made: by which we find, that the *central* force, both of the cylinder and the threads, are cauſed by the *attrition* of the *air* between your hand and the cylinder; whereas, at any other time, they are quite inactive: ſo we are aſſured that theſe *central* forces which have been imagined to be *within* the *ſolid*, are not there, but in the *air without it*.

On putting ſomething between any of the threads and the cylinder; then, thoſe threads would

would return to their firſt and *natural poſition*, viz. point towards the center of the earth. So, as Mr. *Haukſbee* obſerves, "in theſe ſmall orbs of "matter we have ſome little reſemblances of the "*grand phænomena* of the *univerſe*."

Another thing obſervable was, "that by put-"ting theſe threads within a glaſs, when they be-"came extended, this poſition of the threads "would be altered at any time on the approach "of one's hand, finger, or any other body, to "the ſurface of the glaſs." This is ſufficient proof that the *light*, or as it is generally called, the *electrical effluvia paſs* through the *glaſs*, with as much eaſe as water does through a ſieve.

One thing which ſeemed a little ſurpriſing to Mr. *Haukſbee* was, that upon exhauſting the *groſs air* out of the tube or globe made uſe of in electricity, what he called the power of *attraction*, would ceaſe; but upon ſuffering the air again to enter, it returned as vigorous as before. This muſt be the caſe; for (as was before obſerved) whenever the groſs air is extracted by an air pump, the fluid remaining is nothing but *light*. So, whenever this attrition is performed on an exhauſted globe (for want of the reſiſtance of the groſs air within, to force off the particles of air ground ſo ſmall as *light*, and thereby to make an *expanſion* or *rarefaction* round the glaſs globe,

which

which has been ſhewn to be the cauſe of light bodies being *forced* towards the globe) theſe particles of *light* do immediately enter the globe on one ſide, and *force* out the ſame quantity on the other; in the ſame manner as water through a ſieve, without ever making any *expanſion* or *rarefaction*.

Having thus ſhewn how and by what means the *fire* and *light* in electricity are produced; our next inquiry muſt be, why ſome bodies communicate this *light* to ever ſo great a diſtance, and that inſtantaneouſly; whilſt others will not; and alſo, why ſome bodies are *electrical* and others *non-electrical*.

Electrical bodies are thoſe, whoſe *pores* are ſo *fine*, as to admit nothing through them but *light*, or air ground to a proper fitneſs; as *metalls*, *glaſs*, *amber*, *wax* &c. Bodies *non-electrical*, are all thoſe, which, by the *largeneſs* of their *pores*, admit, not only *light* but alſo *groſs air*.

We ſee, when the air is *gound* to pieces by an electrical machine, and *put* into *ſufficient motion*, by the *friction* between the glaſs globe and the hand, a wire being hung from the iron barrel, ſo as very near to touch the ball, part of the *light* iſſuing from the ball, as above deſcribed, *enters* the wire, and is by it communicated to the iron barrel, and from thence *carried* by *another*

wire

wire to any diſtance, if not interrupted by ſome *non-electrical* body: to the end of which, by a third wire is hung an egg; as ſoon as the globe is put in *motion*, and warm ſpirit of wine is placed ſo as to touch the egg, the ſpirit of wine will immediately take fire from the contact of the egg.

It has been already proved, that when the globe is put in *motion*, and your hand is applied to it, it *grinds* to pieces the air between the globe and the hand, and ſo *rarefies* and *expands* it, and ſends it off with great force, in the ſame manner, as *light* is ſent from any body of *fire in action*; as may be ſeen, if the electrical machine is ſet at work in the dark; when the emiſſion from the glaſs globe will appear lucid.

The wires which are hung over the glaſs globe, by the *ſmallneſs* of their *pores*, admitting nothing through them but *light*, and light being a body ſo *ſubtil*, as to penetrate the *pores* of all other bodies, even to the very center of the earth; the *interſtices* of the *wires* are filled with it from one end to the other.

As the *light* is one continued body, throughout the whole extent of the wire, the *force* it receives at the end next the glaſs globe, is *immediately*, and at the *ſame inſtant* of time, communicated to the other end, let the *length* or *extent* of the wire

wire be ever ſo great. As, for example, a pipe of any length, being filled with any ſort of fluid, as water; if you force in more water at one end, the ſame moment, and in the ſame quantity, it will be forced out at the other.

By theſe experiments in electricity, we find that *fire* and *light* are produced as has been before obſerved, only by *breaking* the air to pieces, and putting it in *motion*; and that *fire* and *light* are in *all* bodies, water and ice not excepted; for, if a piece of ice is hung at the end of the wire, it will ſet fire to ſpirit of wine, as well as an egg.

The iron wire by the *cloſeneſs* of its *pores* prevents the ſurrounding air from entering it, and by that means at the ſame time forms a kind of *canal* for the *light* to paſs through.

Having thus as I conceive, given a tolerable clear account, and, I hope, a true one, how and by what means, the various *phænomena* in electricity are produced; I ſuppoſe, it will not be a very difficult taſk, to form a judgment, what diſorders electrical operations are likely to be applied to, with hopes of ſervice; as alſo in what others they are likely to be detrimental.

As the *heat* and *redneſs* of the *blood*, may be eaſily proved, to be in proportion to the *quantity* and *motion* of the *light* it contains; ſo, wherever the blood is *heated* to a great degree, as in *fevers*,

Inflam-

Inflammations of all kinds &c. there we are to expect the worſt and moſt pernicious conſequences, from the uſe of electricity.

But, on the contrary, as the nerves have been proved to act by a ſubtil fluid that paſſes through them, and that they, by the cloſeneſs of their pores, will not admit a fluid to paſs through them, whoſe particles are much larger than thoſe of *light*; the conſequences we muſt often expect from ſuch a make, muſt be obſtructions; and as the *light* in electricity is forced through our bodies and nerves, with great violence, it ſeems very reaſonable to think, that where theſe obſtructions are not too violent, there they may be broken through and removed by its power, of which we have had many inſtances, eſpecially in palſies.

This is alſo confirmed by the ſucceſs of the preſent practice of phyſick; for, the greateſt relief, in theſe caſes, is always found to proceed from *volatile* and *penetrating* medicines. But, care ſhould be taken, not to adminiſter electricity, to a perſon of weak and decayed nerves, inſtead of one whoſe nerves are obſtructed.

F I N I S.